

WO9509298

Publication Title:

VALVE OPERATING MECHANISM FOR INTERNAL COMBUSTION ENGINES

Abstract:

Abstract of WO9509298

The present invention provides in a first aspect, with reference to the Figure, a valve operating mechanism for operating an inlet and/or exhaust valve (32) of an internal combustion engine. The mechanism comprises oscillating cam means (24) mounted for rotation about a first fixed axis (25). Means (20, 21) for oscillating the oscillating cam means (24) is provided which oscillates the oscillating cam means (24) between first and second rotational positions. Rocker means (28) is mounted for rotation about a second axis (29) and the rocker means engages and drives a valve (32). Cam follower means (34) is connected to the rocker means (28) and also engages the oscillating cam means (24). Thus, the rocker means (28) is rocked by the oscillating cam means (24) to drive the valve (32), the cam follower means following the profile of the oscillating cam means (24) between first and second contact positions respectively at the first and second rotational positions of the oscillating cam means (24). The cam follower means (34) is moveable with respect to the rocker means (28) and control means is provided for adjusting the position of the cam follower means (34) relative to the axis of rotation of the rocker means (28) whereby the location of the first and second contact positions on the oscillating cam means (24) can be varied. The present invention provides in a second aspect, again with reference to the Figure, an engine having a camshaft (21) driven to rotate in timed relationship to the crankshaft of the engine and a reciprocating push rod (20) driven by the camshaft (21) which is used to transmit motion to the cylinder head of the engine. The engine is provided with transmission means to transmit motion from the push rod (20) to an inlet or exhaust valve (32) of the engine whereby the valve (32) is driven to reciprocate. The transmission means comprises oscillating cam means (24) directly or indirectly driven by the push rod (20), cam follower means (34), which follows the profile of oscillating cam means (24) and which is in driving connection with the inlet or exhaust valve (32) and means to alter the position of the cam follower means (34) relative to the oscillating cam means (24) which allows the cam follower means (34) to be controlled to follow different surface sections of the oscillating cam means (24) such that valve motion can be varied.

Data supplied from the esp@cenet database - Worldwide

Courtesy of <http://v3.espacenet.com>

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

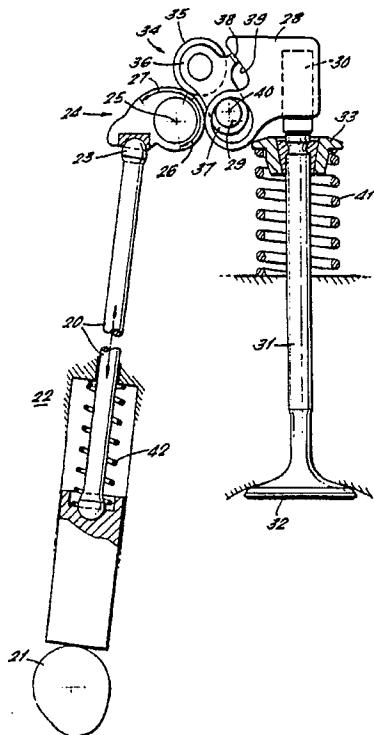
(51) International Patent Classification 6 :	A1	(11) International Publication Number: WO 95/09298
F01L 13/00		(43) International Publication Date: 6 April 1995 (06.04.95)

(21) International Application Number: PCT/GB94/02072	(81) Designated States: JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).
(22) International Filing Date: 23 September 1994 (23.09.94)	
(30) Priority Data: 9320204.2 30 September 1993 (30.09.93) GB	Published <i>With international search report.</i>
(71) Applicant (for all designated States except US): LOTUS CARS LTD. [GB/GB]; Hethel, Norwich, Norfolk NR14 8EZ (GB).	
(72) Inventor; and	
(75) Inventor/Applicant (for US only): ALLEN, Jeffrey [GB/GB]; 4 Sheppard Way, Attleborough, Norfolk NR17 2DG (GB).	
(74) Agent: BOULT WADE TENNANT; 27 Furnival Street, London EC4A 1PQ (GB).	

(54) Title: VALVE OPERATING MECHANISM FOR INTERNAL COMBUSTION ENGINES

(57) Abstract

The present invention provides in a first aspect, with reference to the Figure, a valve operating mechanism for operating an inlet and/or exhaust valve (32) of an internal combustion engine. The mechanism comprises oscillating cam means (24) mounted for rotation about a first fixed axis (25). Means (20, 21) for oscillating the oscillating cam means (24) is provided which oscillates the oscillating cam means (24) between first and second rotational positions. Rocker means (28) is mounted for rotation about a second axis (29) and the rocker means engages and drives a valve (32). Cam follower means (34) is connected to the rocker means (28) and also engages the oscillating cam means (24). Thus, the rocker means (28) is rocked by the oscillating cam means (24) to drive the valve (32), the cam follower means following the profile of the oscillating cam means (24) between first and second contact positions respectively at the first and second rotational positions of the oscillating cam means (24). The cam follower means (34) is moveable with respect to the rocker means (28) and control means is provided for adjusting the position of the cam follower means (34) relative to the axis of rotation of the rocker means (28) whereby the location of the first and second contact positions on the oscillating cam means (24) can be varied. The present invention provides in a second aspect, again with reference to the Figure, an engine having a camshaft (21) driven to rotate in timed relationship to the crankshaft of the engine and a reciprocating push rod (20) driven by the camshaft (21) which is used to transmit motion to the cylinder head of the engine. The engine is provided with transmission means to transmit motion from the push rod (20) to an inlet or exhaust valve (32) of the engine whereby the valve (32) is driven to reciprocate. The transmission means comprises oscillating cam means (24) directly or indirectly driven by the push rod (20), cam follower means (34), which follows the profile of oscillating cam means (24) and which is in driving connection with the inlet or exhaust valve (32) and means to alter the position of the cam follower means (34) relative to the oscillating cam means (24) which allows the cam follower means (34) to be controlled to follow different surface sections of the oscillating cam means (24) such that valve motion can be varied.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

- 1 -

VALVE OPERATING MECHANISM
FOR INTERNAL COMBUSTION ENGINES

The invention relates to a valve operating mechanism suitable for internal combustion engines and in particular to a mechanism which is operable to vary valve lift and timing in different engine operating conditions.

A typical internal combustion engine currently available uses a camshaft in direct or indirect engagement with the inlet and exhaust valves of the engine which controls the opening and closing of the inlet and exhaust valves and the lift of the valves. The camshaft is rotated at a speed proportional to the speed of rotation of the engine and the timing of the opening and closing of the inlet and exhaust valves in terms of degrees of crankshaft rotation after top dead centre (ATDC) in each engine cycle is constant for all engine operating conditions. The cam profile of the camshaft must be chosen to provide a compromise between the cam profile for efficient operation at high engine speeds and the cam profile necessary for efficient operation at low engine speeds.

Several systems have been proposed in the past which provide solutions to the problems of ordinary camshaft driven valve operating mechanisms. For instance in PCT/GB91/00232 and PCT/GB91/00233 mechanisms are shown which allow a first cam profile to be used at low engine speed/loads and a second cam profile to be used by the engine at high engine speed/loads. Whilst the systems provide advantages over the traditional cam operated valve mechanisms they can only provide for discrete definite changes in cam profile and do not allow smooth changes in valve lift and valve timing with engine speed and/or load.

In the U.K. application GB 2047801 there is

The present invention provides a valve operating mechanism for operating an inlet and/or exhaust valve of an internal combustion engine comprising

oscillating cam means mounted for rotation about a first fixed axis,

means for oscillating the oscillating cam means between first and second rotational positions,

rocker means mounted for rotation about a second axis in driving engagement with a valve,

cam follower means connected to the rocker means and in engagement with the oscillating cam means whereby the rocker means is rocked by the oscillating cam means to drive the valve, the cam follower means following the profile of the oscillating cam means between first and second contact positions respectively at the first and second rotational positions of the oscillating cam means,

characterised in that the cam follower means is moveable with respect to the rocker means and control means is provided for adjusting the position of the cam follower means relative to the axis of rotation of the rocker means whereby the location of the said first and second contact positions on the oscillating cam means can be varied.

Preferably the rocker means is rockable about a fixed axis.

A disadvantage the GB 2047801 system arises since the configuration of the apparatus necessitates the provision of three surfaces with sliding friction. The avoidance of friction in any valve operation mechanism is very important since a valve operating mechanism will operate at high frequencies of motion and therefore considerable friction will be generated between sliding surfaces and there will be considerable wear between sliding surfaces. The wear of sliding surfaces is a significant problem in valve operating mechanisms since wear can cause unwanted alteration in valve motion.

- 5 -

cam means comprises connection means for connecting the oscillating cam means to the reciprocating push rod.

Preferably second cam follower means comprising roller means is provided for the engine, the roller means engaging a cam of the camshaft of the engine and following the profile thereof. The roller means will engage the overhead camshaft of an overhead camshaft engine or will be connected to the push rod of a push rod engine. The roller means reduce frictional losses.

In a further aspect the present invention provides an engine having a camshaft driven to rotate in timed relationship to the crankshaft of the engine and a reciprocating push rod driven by the camshaft which is used to transmit motion to the cylinder head of the engine, wherein transmission means is provided to transmit motion from the push rod to an inlet or exhaust valve of the engine whereby the valve is driven to reciprocate characterised in that the transmission means comprises

oscillating cam means directly or indirectly driven by the push rod,

cam follower means which follow the profile of the oscillating cam means and which is in driving connection with the inlet or exhaust valve and

means to alter the position of the cam follower means relative to the oscillating cam means which allows the cam follower means to be controlled to follow different surface sections of the oscillating cam means such that the valve motion can be varied.

GB 2047301 provides a system of valve operation which is suitable for an engine having overhead cam shafts. However, the system provided by the document is not suitable for use in a push rod engine and therefore the problem of providing a valve operating mechanism which allows variable valve timing and valve lift remains outstanding for the push rod engine.

- 7 -

adjustable, the motion of the valve 16 can be varied. Taking the Figure 1 to represent the extreme left position of the adjustable length arm 12, the oscillating motion imposed on the arm 12 will cause the adjustable length arm 12 to move to the right as shown in the drawings and the arm will move relative to the valve stem 17 such that the valve stem 17 moves along the flat portion 14 of the cam surface of the arm 12 and at the extreme right position of the arm 12 just remains in contact with the flat portion 14, giving no lift of the valve 16. This condition would be the minimum valve lift operating condition and this is shown as the line 90 in the graph of Figure 2.

By adjusting the length of the arm 12 the arm is moved relative to the valve stem 17. By increasing the length of the arm 12 the arm moves to the right with respect to the valve stem 17 and therefore for the same distance of oscillatory motion D1 the top of the valve stem 17 moves along a different portion of the cam profile surface of the arm 12. Motion of the valve stem 17 along the ramp 15 causes downward motion and therefore valve lift. With increasing length of the arm 12 the valve stem 17 will move further along the ramp portion 15 of the cam profile surface with correspondingly greater valve lift and longer valve opening duration.

The length of the arm would be adjusted with changes in engine speed and/or load to achieve the lifting duration desirable for particular engine operations. The valve lift lines 90, 100, 110, 120, 130 and 140 of Figure 2 show different valve lift and duration for different engine operating conditions. The line 90 would correspond to valve deactivation and the line 140 would correspond to the maximum lift and duration possible, which would be used at high engine speeds or loads.

A first embodiment of the invention is shown in Figure 3 of the application, which embodiment is suitable for use with a push rod engine. The drawing shows the push rod 20 which is driven by a camshaft 21 to reciprocate in a bore in the cylinder block of the engine 22. The push rod 20 is connected at its upper end by a pivot joint 23 to cam means 24. The cam means 24 comprises a member rotatable about a fixed pivot axis 25. The cam means 24 has a cam profile along its outer surface. The cam profile includes a first portion 26 of constant radius and a second portion 27 of increasing radius.

A rocker 28 is rockable about a fixed pivot axis 29. A hydraulic lash adjuster 30 is located in the rocker 28 and contacts the top of a valve stem 31 of a cylinder head valve 32 of an engine. A valve spring 41 acts between the cylinder head and a collar 33 attached to the valve stem 31 to bias the valve 32 into its valve seat.

The rocker 28 is provided with cam follower means 34 which follows the surface of the cam means 24. The cam follower means 34 comprises a cam follower roller 35 rotatably mounted on a link member 36. The link member 36 is connected at its lower end to a shaft (not shown in the drawing for reasons of clarity) which extends through aperture 37. The rocker arm 28 is rotatable with respect to the shaft about the axis 29 which is the principal axis of the shaft. The link 36 is rotatably connected to the shaft for rotation about an axis 40 which is offset from the axis 29.

The link member 36 has abutment means 38 for abutting the reaction surface 39 provided on the rocker arm 28.

The shaft can be rotated to rotate the axis 40 of the rotatable mounting of link 36 about the fixed axis 29 of the rocker arm 28 such that the distance between

the axis 29 and the point of contact between the roller 35 and cam means 24 is varied.

The shaft is rotated relative to the rocker arm 28 by suitable motor means to effect adjustment. Since the pivot point 40 of the link 36 is attached to the shaft, rotation of the shaft relative to the rocker arm 28 causes movement of the pivot point 40 relative to pivot point 29 and corresponding movement of the link 36 relative to the rocker arm 28.

Considering now the operation of the arrangement shown in Figure 3 in use of the apparatus the camshaft 21 will be driven to rotate at the rotational speed proportional to the rotational speed of the crankshaft of the engine, being driven by suitable connection means. The cam surface on the camshaft 21 causes reciprocal motion of the push rod 20, which in turn causes the cam means 24 to oscillate about the pivot axis 25. As the cam means 24 rotates about its axis 25 the roller 35 of the cam follower means of the rocker arm 28 moves along the cam profile surfaces 26 and 27. The valve 32 remains on its seat whilst the roller 35 moves along the surface 26, because the surface 26 is of constant radius. However, when the roller starts to move along the surface 27 the rocker arm 28 is caused to rotate clockwise about the fixed pivot point 29 and to cause the valve 32 to move downwardly and open the associated port in the engine cylinder.

Eventually, the push rod 20 will move downwardly in the cylinder block, following the profile of the camshaft 21, under the influence of a spring 42 acting between the cylinder block 22 and the push rod 20. The push rod 20 will pull the cam means 24 in a counterclockwise direction on downward motion and the roller 35 will move from the cam profile section 27 to the section 26 of the cam profile surface, with the

- 10 -

valve 32 being allowed to return to its valve seat under the biasing action of the valve spring 41. The valve spring 41 exerts a biasing force to maintain contact between the roller 35 and cam means 24.

As shown in the Figure 3, the mechanism is in its position for maximum valve lift and maximum duration of valve lift. With the valve 32 in its position against the valve seat the cam follower roller is positioned just at the beginning of the cam profile lifting surface 27. Any motion of the cam means 24 in a clockwise direction will cause valve lift. Such an operating condition will be ideally suited for high engine speeds or loads when it is required to obtain a large degree of valve opening in each cycle since there is little time for flow of gases in each cycle due to the brevity of each cycle at high engine speed.

At lower engine speeds or loads less valve lift and a short valve opening period is required for efficient operating of the engine and this is achieved by rotating the control shaft of the apparatus such that the pivot point 40 is rotated relative to the fixed pivot point 29. The distance between the pivot point 29 of the rocker and the axis of rotation of roller 35 is thus varied, with the abutment means 38 moving along the reaction surface 39. Since the roller 35 is moved relative to the rocker arm 28 it will roll along a different portion of the cam profile surface of the cam means 24. A change in valve timing and valve lift will thus be occasioned.

The operation principle is illustrated in Figures 4A and 4B, 5A and 5B and 6A and 6B.

In Figure 4a the cam means 24 is in its idle position (i.e. when the push rod 20 is moving along the base circle portion of the cam 21).

Cam means 24 is then rotated through a set number of degrees by the push rod 20 to its position of maximum

- 11 -

clockwise rotation shown in Figure 4b. The rotational axis of roller 35 is at a distance Y_1 from the rotational axis 29 of the rocker arm 28. Y_1 is the maximum distance possible in the embodiment.

The roller 35 during the idle portion of the cam means 24 is in contact with a point X_1 on the cam profile surface which is a distance R_1 from the rotational axis 25 of the cam means. The distance R_1 is chosen such that the valve means 32 is in contact with its valve seat.

Throughout the clockwise rotation of the cam means 24 the roller 35 moves along the cam profile surface with increasing radial distance from the rotated arms 25 until it reaches the maximum displacement at X_2 (a distance of R_2 from the axis of rotation 25). The process is then reversed for counter clockwise motion of the cam means 24.

Considering now Figures 5A and 5B the distance between the centre of rotation of the roller 35 and the axis of rotation 29 of the rocker arm 28 has been altered to Y_2 , where Y_2 is less than Y_1 . Consequently, the roller 35 is positioned during the idle portion of the motion of the cam means 24 at a position X_3 on the cam profile surface, which is at a radial distance R_3 from the centre of rotation 25 of the cam means 24. The radial distance R_3 is chosen to be a distance which allows contact of the valve 32 with its valve seat.

As the cam means 24 is rotated clockwise the roller 35 moves from position X_3 through position X_4 to position X_5 , the position at maximum clockwise rotation of the cam means. Whilst the roller 35 moves between positions X_3 and X_4 it is not displaced radially of the cam means 24, since the distance R_4 at X_4 is the same as the distance R_3 at X_3 . Consequently, the valve 32 is maintained in its closed position.

When the roller 35 moves from X_4 to X_5 it moves

over a cam profile surface of increasing distance from the axis of rotation 25 (R5 being greater than R4). Consequently, the valve is lifted from its valve seat. However, comparing 5B with 4B it will be noticed that the radial distance R5 is less than R2 and the maximum valve lift occasioned with the mechanism operating as shown in 5A and 5B is less than the maximum valve lift achieved at 4B.

The mechanism is provided with the possibility of valve deactivation as shown in Figures 6A and 6B. With a distance Y3 chosen between the axis of rotation of roller 34 and the axis of rotation 29, the roller 34 moves from a position X6 on the cam profile surface to a position X7. Both distances R6 and R7 are the same and both are chosen such that the valve 32 remains against its valve seat. Consequently, the valve 32 remains inactive throughout rotation of the cam means 24.

The second embodiment of the invention illustrated in Figure 7 is suited to use in an overhead camshaft engine. The overhead camshaft of the engine is shown as 50 in the Figure. The operation of the overhead camshaft embodiment is substantially the same as the operation of the push rod embodiment already described and will not be further commented on. However, there are two significant differences between the mechanisms of the two embodiments.

The first difference is an alteration in the cam means. Cam means 24 present in the first embodiment has been replaced by cam means 51. The cam means 51 is rotatable about an axis 25 in identical fashion to the cam means 24 and the cam means 51 has cam profile surfaces 27 and 26 which are identical to those of the cam means 24. The difference between the cam means 51 and 24 is the provision of a cam follower surface 52 connected to the cam means 51 which follows directly the profile of the overhead camshaft 50 of the overhead

camshaft engine in which it is used.

The second difference between the embodiments of Figures 3 and 7 is the replacement of the spring 42 with a light spring 53. The light spring 53 keeps the cam follower surface 52 of the cam means 51 in engagement with the cam 50.

In both of the first and second embodiments of the invention (Figures 3 and 7) the control shaft (not shown) will be driven to rotate by an electric motor (not shown) controlled by a suitable electrical or electronic controller. Sensors will be provided to measure various engine parameters (eg. speed, load and temperature) and provide signals indicative of the measured parameters to the controller. The controller will typically be an electronic controller having a memory map of optimum operating instructions for various combinations of inputs. The controller will generate suitable control signals to control the electric motor.

In the above embodiments it will be noted that friction is kept to a minimum since sliding contact is required only between the cam shafts 21 and 50 of and cam follower members. The contact between the rocker arm 28 and the cam surfaces 26 and 27 is provided by a roller which is used to minimise frictional losses and to minimise wear. Rollers could also be included as cam follower means to engage the cam means 21 and 50 and this would further reduce frictional losses.

The valve operating mechanisms are compact in nature and facilitate the use of hydraulic lash adjustors.

It will also be seen that the invention provides a valve mechanism suitable for a push rod engine.

CLAIMS:

1. A valve operating mechanism for operating an inlet and/or exhaust valve of an internal combustion engine comprising

oscillating cam means mounted for rotation about a first fixed axis,

means for oscillating the oscillating cam means between first and second rotational positions,

rocker means mounted for rotation about a second axis in driving engagement with a valve,

cam follower means connected to the rocker means and in engagement with the oscillating cam means whereby the rocker means is rocked by the oscillating cam means to drive the valve, the cam follower means following the profile of the oscillating cam means between first and second contact positions respectively at the first and second rotational positions of the oscillating cam means,

the cam follower means is moveable with respect to the rocker means and control means is provided for adjusting the position of the cam follower means relative to the axis of rotation of the rocker means whereby the location of the said first and second contact positions on the oscillating cam means can be varied.

2. A valve operating mechanism as claimed in Claim 1 wherein the rocker means is rockable about a fixed axis.

3. A valve operating mechanism as claimed in Claim 1 or Claim 2 wherein the cam follower means comprises a roller in contact with the oscillating cam means mounted for rotation on a link member connected to the rocker means, which link member is moveable by the control means to move the roller relative to the rocker means.

- 15 -

4. A valve operating mechanism as claimed in Claim 3 wherein the rocker means is mounted on a shaft and is rotatable relative thereto, the link member is eccentrically mounted on the shaft, and the control means comprises means to rotate the shaft whereby the link member and the roller are moved relative to the rocker means.

5. A valve operating mechanism as claimed in any one of the preceding claims wherein a hydraulic lash adjuster is provided in the rocker means, which hydraulic adjuster has a surface which abuts the top of the valve stem of the inlet or exhaust valve.

6. An engine having an inlet or exhaust valve with an associated valve seat operated by a valve operating mechanism as claimed in any one of the preceding claims wherein the inlet or exhaust valve is biased into the associated valve seat by a valve spring and the biasing force of the valve spring is used to maintain contact between the cam follower means and the oscillating cam means when the valve is lifted from the associated valve seat.

7. An engine as claimed in Claim 6 or having an inlet or exhaust valve operated a valve operating mechanism as claimed in any one of claims 1 to 5, which engine has a rotating overhead camshaft for driving the valve wherein the means for oscillating the oscillating cam means comprises second cam follower means provided on the oscillating cam means which engage a cam of the overhead camshaft and follow the cam profile thereof.

8. An engine as claimed in Claim 6 or having an inlet or exhaust valve operated by a valve operating mechanism as claimed in any one of claims 1 to 5, which engine has a camshaft mounted in the lower half of the engine with

- 16 -

a reciprocating push rod driven thereby which transmits motion to the cylinder head, wherein the means for oscillating the oscillating cam means comprises connection means for connecting the oscillating cam means to the reciprocating push rod.

9. An engine as claimed in Claim 7 or Claim 8 wherein second cam follower means comprising roller means is provided for engaging a cam of the camshaft of the engine and following the profile thereof.

10. An engine having a camshaft driven to rotate in timed relationship to the crankshaft of the engine and a reciprocating push rod driven by the camshaft which is used to transmit motion to the cylinder head of the engine, wherein transmission means is provided to transmit motion from the push rod to an inlet or exhaust valve of the engine whereby the valve is driven to reciprocate characterised in that

the transmission means comprises oscillating cam means directly or indirectly driven by the push rod

cam follower means which follows the profile of the oscillating cam means and which is in driving connection with the inlet or exhaust valve, and

means to alter the position of the cam follower means relative to the oscillating cam means which allows the cam follower means to be controlled to follow different surface sections of the oscillating cam means such that the valve motion can be varied.

11. A valve operating mechanism substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

114

FIG. 1.

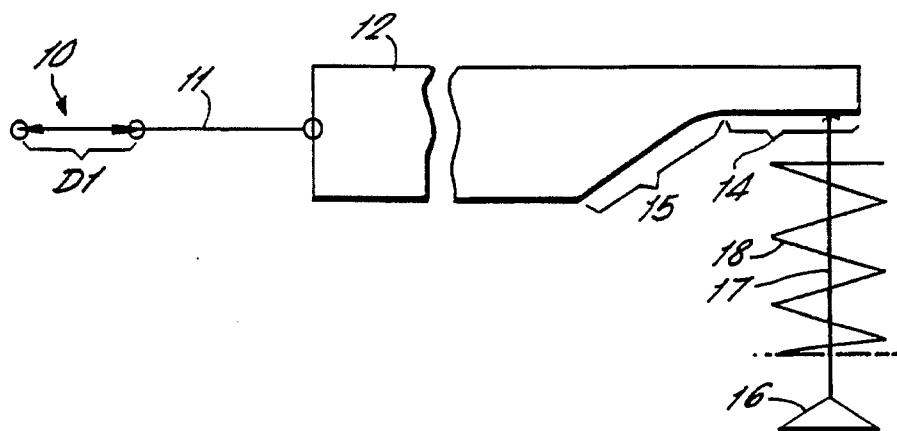
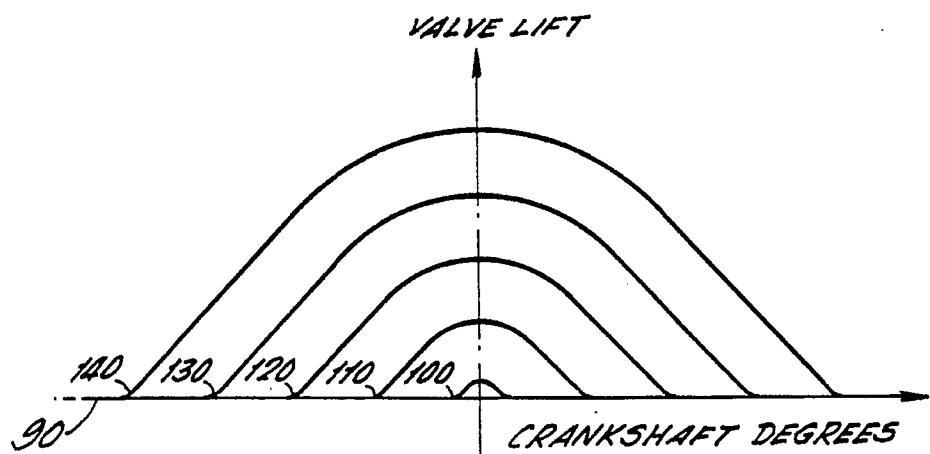
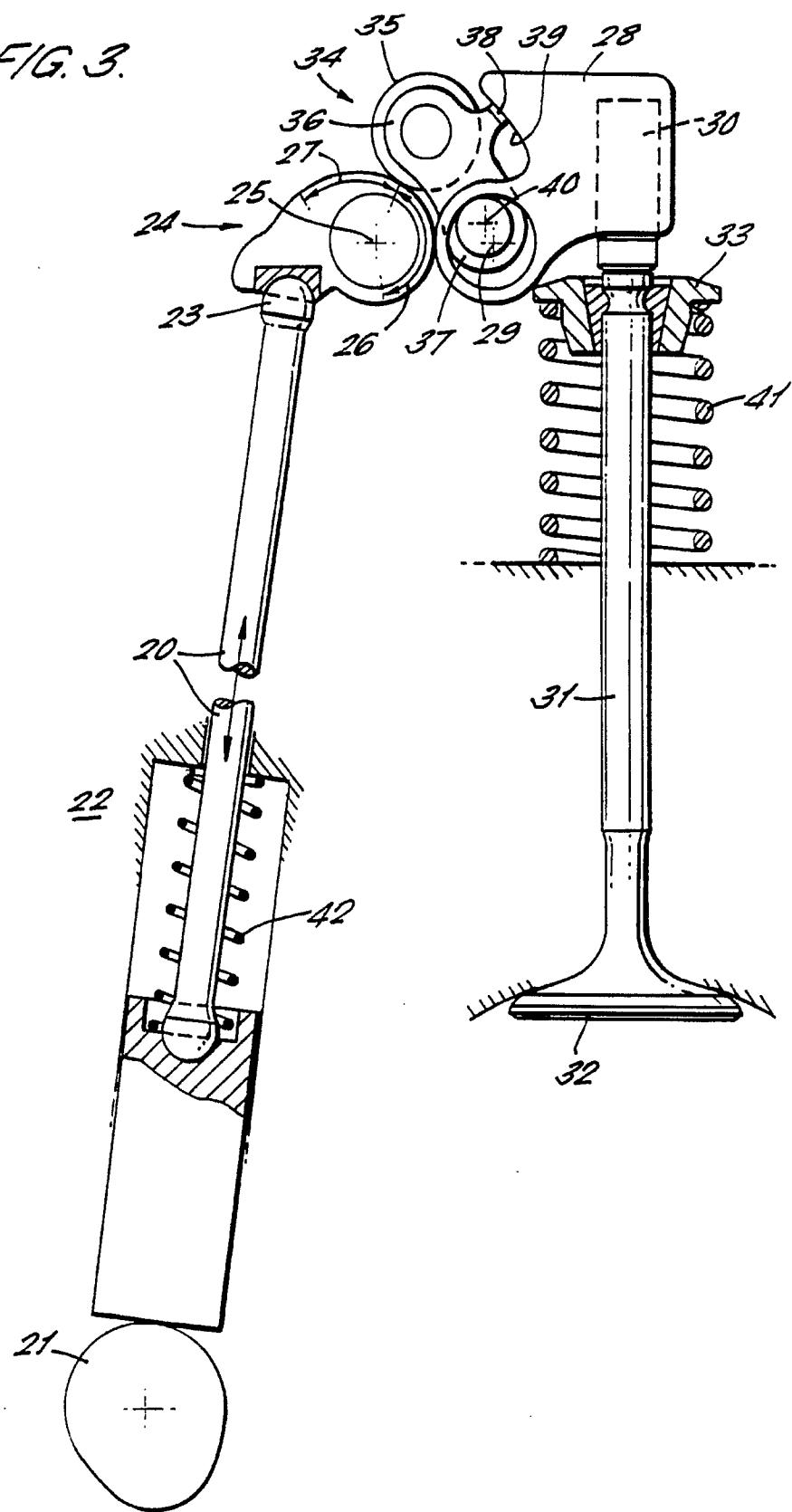


FIG. 2.



214

FIG. 3.



314

FIG. 4A.

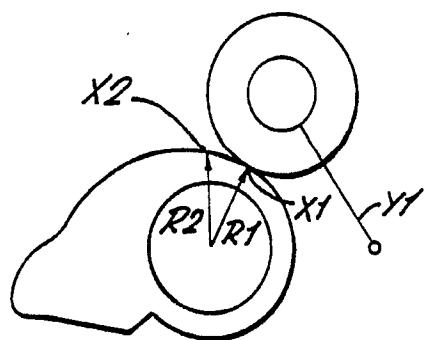


FIG. 4B.

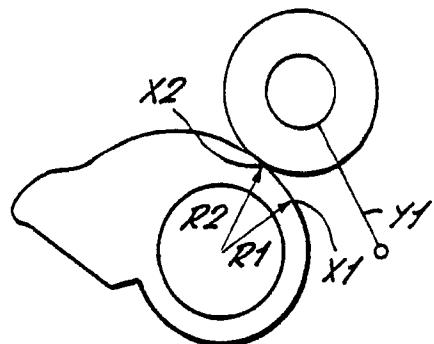


FIG. 5A.

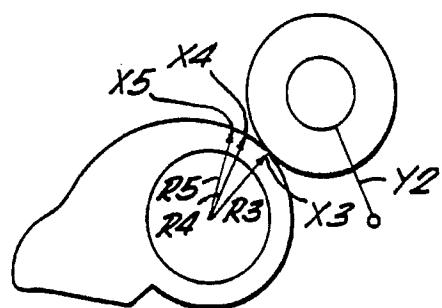


FIG. 5B.

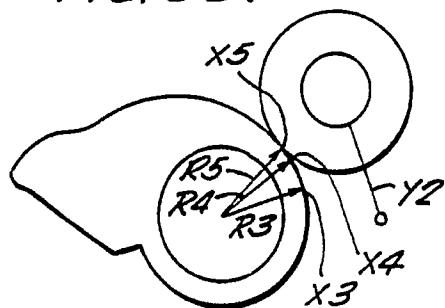


FIG. 6A.

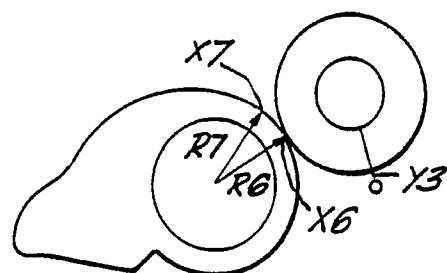
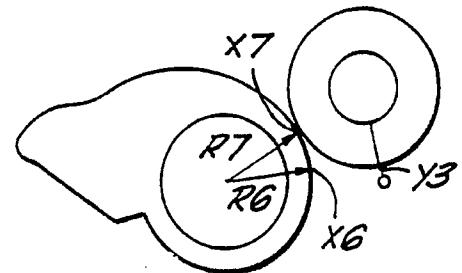
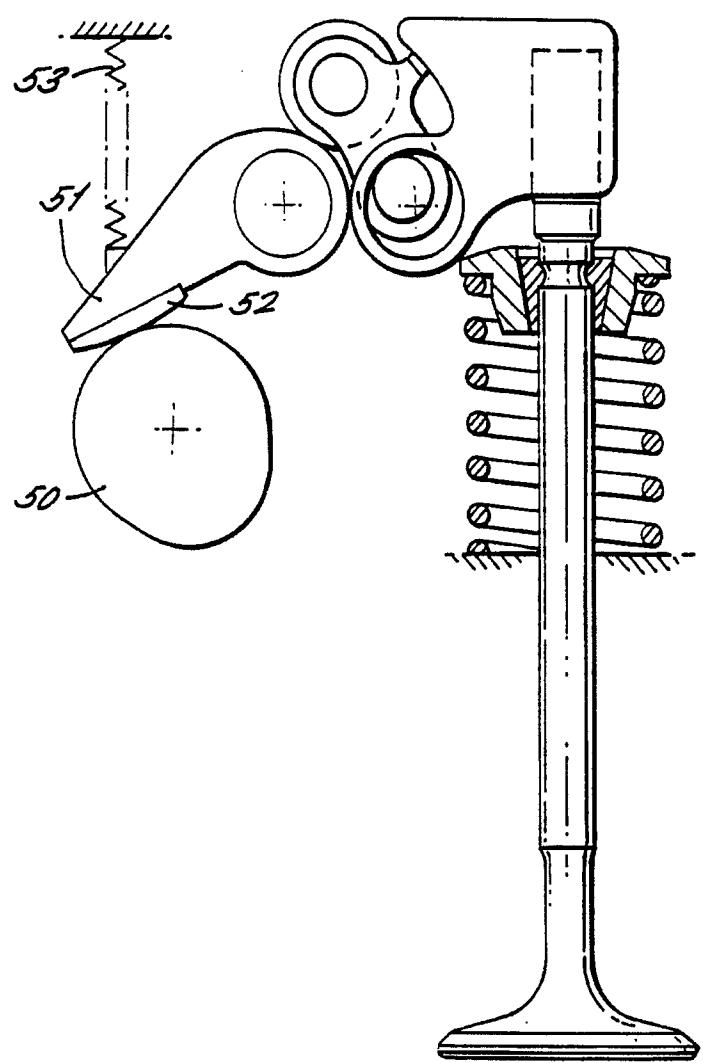


FIG. 6B.



4 / 4

FIG. 7.



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 94/02072

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F01L13/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB,A,J06650 (JUDD) 14 October 1909 &GB-A-06650 A.D. 1909	1,2,10
A	see page 1, line 7 - line 41; figure 1 ---	3,6,8,9
A	EP,A,0 280 667 (AB VOLVO) 31 August 1988 see column 3, line 60 - column 5, line 5 see figure 3 ---	1,2
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 92 (M-468) 9 April 1986 & JP,A,60 228 716 (SUZUKI JIDOSHA KOGYO KK) 14 November 1985 see abstract ---	1
A,P	DE,A,42 20 816 (INA WALZLAGER SCHAEFFLER KG) 5 January 1994 -----	

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *I* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

Date of the actual completion of the international search

14 December 1994

Date of mailing of the international search report

23.12.94

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Fax. 31 651 cpo nl,
Fax: (+31-70) 340-3016

Authorized officer

KLINGER, T

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 94/02072

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
GB-A-J06650		NONE		
EP-A-0280667	31-08-88	SE-B-	464367	15-04-91
		DE-A-	3867255	13-02-92
		JP-A-	63230915	27-09-88
		SE-A-	8700820	27-08-88
		US-A-	4829949	16-05-89
DE-A-4220816	05-01-94	NONE		